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Running Head: Syllabic structure and reading

Abstract

The central hypothesis of this study was that phonological mediation plays a critical role in the early development of reading and spelling in French. Therefore, the phonological structure of items, as opposed to their visual characteristics, was expected to be a significant determinant of performance. This hypothesis was tested in a short term longitudinal study with a group of first graders (N=57) who were administered a reading and a spelling task involving pseudowords of different syllabic structures. The first prediction was that there would be better performance on pseudowords with a simple structure (CVCVCV) as compared to pseudowords with a complex structure (CCVCVC or CVCCVC) and that errors on syllables with a complex structure would involve the deletion of codas or the simplification of complex onsets. Secondly, we predicted that errors would be consistent with a sonority hierarchy, for example, we expected more deletions of liquids than obstruents in clusters. Thirdly, we predicted that the principal phonological categories and not the visual characteristics would be preserved in substitutions (for example, stops would be substituted by stops). Our fourth prediction was that the structural characteristics of French would influence performance, specifically, the frequency of open syllables in French would result in superior performance on CV and CCV (open) syllables in contrast to CVC (closed) syllables and in the deletion of codas in closed syllables. Moreover, because of the stability of vowels in French, we expected few errors involving vowels. The findings corroborated the predictions, except for the failure to find differences between open and closed syllables. The results confirmed the importance of phonological mediation in the initial stage of the acquisition of reading and spelling.

According to most developmental models of reading and spelling, phonological mediation plays an important role in the learning of these skills and is characteristic of the early phases of acquisition (e.g., Frith, 1985, 1986; Morton, 1989; Seymour, 1986). In this phase, the child uses the relations between graphemes and phonemes in reading and spelling. Reading and spelling with phonological mediation are, by definition, sensitive to the orthographic regularity of items (e.g., Backman, Bruck, Hebert & Seidenberg, 1984; Seidenberg, Waters, Barnes & Tanenhaus, 1984; Waters, Seidenberg & Bruck, 1984). However, there are other phonological characteristics that might reasonably be expected to influence performance at this stage, but relatively few studies of the effects of phonological structure of items on the acquisition of reading and spelling skills have been conducted. Moreover, most of this research has been limited to the study of English language (e.g., Goswami & Bryant, 1990; Treiman, 1993).

The present study was designed to examine the effects of phonological structure on the initial stages of the acquisition of reading and spelling in French. If phonological mediation is important in reading and spelling from the initial stages of acquisition, then the characteristics of the phonological structure of items, as opposed to their visual characteristics, can be assumed to be the most significant influences on reading and spelling performance. One of these phonological characteristics is the structure of the syllable, in particular the division of the syllable into onset and rime. The basic structure of the syllable is a simple onset and a rime without a coda, that is a single consonant and vowel (CV, Clements & Keyser, 1983). It should be noted that the CV syllable exists in all languages and that there are languages composed with only the CV syllabic structure. Thus, superior performance in the early acquisition of reading and spelling skills can be expected on items with this simple CV structure, compared to items that contain a consonant cluster in the onset (CCV) or a rime with a coda (CVC).

It also can be expected that the errors for items with a complex syllabic structure will be primarily errors that involve the deletion of codas or the simplification of complex onsets. Specifically, if phonological mediation is a critical determinant of performance, errors will be consistent with the hierarchy of sonority (Clements, 1990), that is, that the most sonorant consonants will be the elements most likely to be deleted because sonorant consonants are those that are phonologically closest to vowels. Therefore, glides and liquids, as compared to obstruents, are more likely to be assimilated into vowels, whether they occur after a less sonorant consonant in a complex onset or in an intersyllabic coda before a less sonorant consonant (for example, early in speech development, deletion of the "r" in "crab" or of the "l" "cold"). In addition, "because the basic phonological categories are typically assumed to be consonant (C) and vowel (V) the claim is that consonants slip with consonant and vowels slip with vowels" (Dell, Juliano & Govindjee, 1993, p.153). Thus, it can be assumed that the main phonological categories will be preserved; vowels will be substituted for vowels and consonants for consonants. Consistent with this principle, the majority of the substitution errors for consonants are expected to be of the same phonological category, e.g., stops for stops, fricatives for fricatives, and liquids for liquids.

These general principles are expected to operate in all languages with certain variations according to the language in question. For example, in English the majority of syllables have a closed structure; in French there is a preponderance of open syllables (See for example, Clement, 1990; Delattre, 1965; Dell, 1990; Encrevé, 1988; Kaye & Lowenstamm, 1984). According to Delattre (1965, 1966), oral French is typically composed of 79% open syllables (54.9% of CV

and 14.2% of CCV) as opposed to 19% closed syllables (17.1% of CVC and 1.9% of VC). These percentages may fluctuate according to the method and to the corpus used for counting the syllables. However, whatever the technique and the corpus used to count the syllables, the large majority of the syllables in French are open. Therefore, in French, performance on open syllables of the type CV or CCV can be expected to be better than on closed syllables with a coda (CVC). In addition, there is a high stability of French vowel quality whatever the position (Delattre 1965, 1966). Thus, it is expected that there will be relatively fewer errors on French vowels.

In general, previous studies support the hypotheses of the effects of syllabic structure on reading performance. For example, Prinzmetal, Treiman and Rho (1986) required anglophone subjects to name the color of a letter written in the third position of a bisyllabic word of five letters. The words were written in two colors that were either consistent or inconsistent with the syllable boundaries. The results showed that the subjects tended to attribute the color of the target letter to the color of the syllable in which it occurred independently of the bigram frequency, thus showing the importance of syllabic structure.

A series of experimental and naturalistic studies by Treiman (for a summary see Treiman, 1992, 1993) corroborate, in general, the effects of phonological characteristics on spelling and reading acquisition in English. Treiman (1991) has shown that kindergarten and first grade children tended to make errors in spelling that involved simplification of complex onsets by omitting the second element of a complex onset whether or not it was in the initial syllable; the initial consonant of these complex onsets was less likely to be omitted or changed.

Concerning the question of vowels, a number of studies have shown that there were more errors on vowels than on consonants in English because of the absence of stability and predictability of English vowels (for reading: Bryson & Werker, 1989; Fischer, Liberman & Shankweiler; 1977; Fowler, Liberman & Shankweiler, 1977; Fowler, Shankweiler & Liberman, 1979; Siegel & Faux, 1989; for spelling: Stage & Wagner, 1992; for reading and spelling: Roeltgen, 1992; Treiman, 1993). This was not the case for other language in which vowels have a high stability and in which the grapheme-phoneme correspondences are more regular than in English, for example, Serbo-Croatian (Ognjenovic, Lukatela, Feldman & Turvey, 1983), German (Wimmer, 1993) and Italian (Cossu, Gugliotta & Marshall, 1995; Cossu, Shankweiler, Liberman & Gugliotta, 1995).

The question of the spelling of vowels was studied by Treiman, Berch, Tincoff & Weatherston (1993) in an examination of the vocalic consonants, that is, those at the peak of the syllable, for example "r" in "sir". In this case, the sound that corresponds to the vowel grapheme is absent in oral speech and syllable does not contain a phonological coda. In contrast, words such as "sip" are composed of an onset + a vocalic peak + a coda. The hypothesis of their study was that if the performance of children at the beginning of the acquisition of spelling is determined by phonological and not visual principles, then they would be more deletion or inversion of vowels on words of the type "sir" than on words of the type "sip". Alternatively, if performance is determined by the visual, and not the phonological characteristics of the stimuli, there would be no difference between items of the type "sir" and those of the type "sip". The data obtained with children in kindergarten and in first and second grades showed that there were more sequence errors ("sir" spelled as "sri") and deletion ("sir" spelled as "sr") for items of the type "sir" than for those of the type "sip". Treiman et al. (1993) have also found that deletions and sequence errors for vowels were more frequent when the consonant which constituted the peak of the syllable was a liquid than when it was a nasal. Similar results were reported by

Treiman from a observational study (1993), that is, 60-65% of deletions occurred for "r" and "l" as opposed to 37% for nasals. More generally, she observed that sequence errors were more frequent when a vowel preceded a sonorant (liquid or nasal) than when it preceded an obstruent (stop or fricative). Those different kinds of errors are consistent with the sonority hierarchy. According to the hierarchy of sonority, liquids are more sonorant than nasals which are more sonorant than fricatives and stops; the most sonorant elements are more likely to be substituted or assimilated into the vowel (Clements, 1990).

An important implication of the results of the Treiman et al. study concerns the reversals of sequences ("sri" for "sir") which shows that although these errors are often labelled visual (Boder, 1973; Orton, 1937) they can also be considered phonological. Specifically, substitutions among the consonants "p" and "b" or "b" and "d" are often considered as visual errors (e.g. Boder, 1973; Orton, 1937). However, these letters are from the same phonological category (stops). If these errors are truly visual errors, there will be more substitution errors between "p" and "b" or between "b" and "d" than between their phonological equivalents, "t" and "d" and "p" and "t". Alternatively, if "p/b" and "b/d" substitutions are phonological in nature, there will be as many substitutions between "p" and "b" as between "t" and "d" (voice/voiceless substitutions) and as many substitutions between "b" and "d" as between "p" and "t" (place of articulation errors). Several studies have noted that these types of errors may be linked to phonological problems rather than to visual difficulties (see Fisher et al., 1977; Fowler et al., 1977; Fowler et al., 1979; Liberman, Shankweiler, Orlondo, Harris & Bell-Berti, 1971). In a study comparing several groups of disabled and normal readers, Werker, Bryson & Wassenberg (1989) noted also that there were more substitutions of phonological features (for example, voice/voiceless) than of visual features (orientation/reversal). These results show the phonological origin of certain types of errors often considered visual. They show also that the classic type of errors made by dyslexics and considered visual in origin (Orton, 1937) may actually be phonological errors (See Vellutino, 1979, for an extended discussion of these issues).

Almost all of the studies of these questions have been conducted in the English language; however, the phonological characteristics of each language may influence the acquisition of reading and spelling skills. There are only few studies that have compared the acquisition of reading and spelling in different languages: English speaking children were compared to Czech-children (Caravolas & Bruck, 1993), to German children (Wimmer & Goswami, 1994) and also to Italian children (Cossu, Shankweiler, Liberman & Gugliotta, 1995). For example, Caravolas and Bruck (1993) compared the performance of Czech and English speaking children on a variety of tasks including spelling. The main hypothesis of this study is that, if language has an effect on performance, then Czech children would be expected to make fewer errors than anglophones on CCV items because of their experience with complex onset. The results were consistent with the predictions. With the exception of this last study, there are, to our knowledge, no other cross linguistic studies concerning the effects of syllabic structure on reading and spelling at the beginning of the acquisition of these abilities.

The present study, which was not a cross linguistic one, was designed to evaluate the influence of the phonological structure of the items on the performance of French beginning readers and spellers. The study was a short-term longitudinal one in the first grade, the first year in which reading and spelling are taught in France. The performance of children (correct

responses and type of errors) for pseudowords of different syllabic structure were examined (CV, CVC, and CCV syllables). This study was designed to test the following hypotheses:

Hypothesis l. A simple onset and a rime without a coda constitute the basis of the syllable; therefore, it can be expected that reading and spelling performance would be superior for items with a simple syllabic structure (CV) than on items with a more complex syllabic structure of the type CCV or CVC. In addition, this hypothesis predicts that certain types of errors will be more common, specifically, the simplification of complex onsets (from CCV to CV) and the deletion of codas (CVC to CV).

Hypothesis 2. It was hypothesized that errors would respect the hierarchy of sonority, for example, liquids would be more likely to be omitted than stops independently of their place, before or after a less sonorant consonant**.**

Hypothesis 3. In the phase of the acquisition of reading and spelling when phonological mediation is the primary process, the errors will be of a phonological and not of a visual nature. Therefore, substitutions will typically involve vowels replaced by vowels, and consonants by consonants. Consonants will be replaced by consonants of the same phonological category, that is, stops by stops, fricatives by fricatives, and liquids by liquids. In addition, in the case of stops, there will be as many substitutions between "p" and "b" or "b" and "d" as between "t" and "d" or "p" and "t" which are all phonologically closely related. On the other hand, if visual errors predominate, then there should be more "b/d" and "p/b" substitutions.

Hypothesis 4. The structure of the French language involves significantly more open than closed syllables and, therefore, it can be expected that there would be better performance on syllables of the structure CV than on syllables of the structure CVC, and better performance on CCV than CVC syllables. Moreover, because of the high stability of French vowels, relatively few errors would be expected on vowels in spelling and in reading in French. Although in French, as in English, there are more alternative spellings for the sound of a vowel than there are for consonants, in French, as opposed to English, there is a high stability of vowel quality, independent of position in the word (Delattre, 1965, 1966).

Method

Subjects

A group of 57 children (mean age in January 77.91 months, sd 3.18) were tested in the months of January and June in the first grade, the first year of reading instruction in France. The children attended 20 different classes in 9 different schools in various areas in the suburbs of Paris. They came from different socioeconomic levels representative of French society. The teachers all used different "mixed" methods, with variations in regard to when grapheme-phoneme correspondence rules were explicitly taught.

Stimuli

Three types of eight pseudowords of different syllabic structures were used. The items in the first two types had a closed syllable in the final position (CVC) but one began with a closed syllable (CVCCVC items: for example, tirbul), and the other began with an open syllable with an initial consonant cluster (CCVCVC items, for example tribul). The items of the third list had a CV structure (CVCVCV items; for example tibulo). All of the items had the same number of letters and phonemes, and the same letter was never used twice in a particular item. In order to examine the nature of the errors, several variables were manipulated.

We used 4 stops, 2 fricatives and 2 liquids (8 out the 18 French consonants[1]). All of the onsets began with a stop or a fricative, with the exception of the third syllable of the CVCVCV items that began with a liquid. Only the stops p, t, b, d and the fricatives f, v were used and all the stops appeared in the same environment, before a liquid (tr), after a liquid (rt) or before a vowel. Furthermore, when two stops appeared in the same item, they always differed by two phonological features (voicing and place of articulation). These stimuli were selected to permit the comparison between, on the one hand, p/b and t/d (voiced/voiceless errors) and, on the other hand, between b/d and p/t (place of articulation errors). These stimuli allow us to determine if there are more of the so called visual errors (substitutions among b, d and p) than non visual, cleanly phonological, ones (substitutions between p and t or between t and d). In addition, the hierarchy of sonority and sonority contrasts were manipulated. Therefore, for consonants, adjacent elements were not too close to each other in sonority rank (minimal distance constraint, for example, stop + liquid), the codas at the end of non terminal syllables were of a higher level of sonority than the subsequent onset (syllable contact low, for example, liquid + stop) and in the complex consonant onsets, the most sonorant consonant (i.e., the liquid) was always in the second position. The different contrasts were maximized by the exclusive utilization of liquids as the second consonant of the onset clusters and as the coda.

The choice of the vowels, and the relationships between consonants and vowels, were designed to be consistent with speech motor theory and with data for the French language (see Boysson-Bardies, 1994; Boysson-Bardies & Durand, 1991; Boysson-Bardies & Vihman, 1991; Davis & MacNeilage, 1990). We used three vowels, two high with one front (i) and one central (u, /y/), and one back central (o). The first two vowels, which are very close in articulation, were used in all consonant environments in the first two syllables. The other vowel (o) was only used in the third syllable of the tri-syllabic items. We select only simple grapheme vowels that can be compared with the simple grapheme consonants we used. Complex grapheme vowels (ou, in, an, on, un), vowels with a diacritic mark (é, è) and context dependent vowels (e) were excluded. Three out the 5 French simple grapheme vowels (and 3 out of the 10 French vowels[2]) were used.

In order to avoid possible interference effects in the reading/spelling of these items which are very similar both in phonological and orthographical features (but which were easy to pronounce in French), the 24 experimental items were inserted in a list including 24 other pseudowords which were not structured in the same way than the experimental ones. These pseudowords were made from words, by changing one to four letters (for example, tamedi, lople, sinope, moube, loumi[3]).

All those items were presented in a random order, the same for each subject. The experimental items are listed in the appendix.

Tasks

For the reading task, each child was required to read the pseudowords aloud and was told they were words from the "Martian language". The items were presented individually in the center of the screen of a microcomputer. A font (7 x 5 mm.) comparable to that used in readers was designed especially for this study. The microcomputer was equipped with a voice card that allowed the recording of responses. During the session the responses were recorded both by the experimenter and the computer and subsequently compared. Because of the regularity of the items, the coding of the responses was not particularly difficult. In the case of spelling, a

response was considered correct if it resulted in the pronunciation of the item dictated to the child.

Three familiarization trials were administered immediately prior to the testing session. For those trials and for the test session, the children were not given any feedback about the nature of their responses.

For the spelling task, the same items were dictated to the children. The experimenter said the item once, asked the child to repeat it, and then said the item a second time. The spelling task was given one or two days after the reading test. As was the case for the reading test, no feedback was provided during the spelling test.

Results

Reading: Analysis of correct responses

The mean number of correct responses on the reading and spelling tasks is shown in Table 1. The performance on the reading task more than doubled between the sessions, 30% correct responses in the first session and 72% for the second. A 2 way ANOVA of Session and Syllabic Structure indicated that there was a significant difference between sessions ($F(1,56)=109.49$, $p<.01$), a main effect of syllabic structure ($F(2,112)=14.58$, $p<.01$) and a Syllabic Structure x Session interaction ($F(2,112)=3.65$, $p<.05$). This interaction was the result of the fact that the difference among the three types of items decreased between the sessions. However, the main effect of syllabic structure was the result of better performance on simple items as opposed to complex items (effect of syllabic complexity: $F(1,56)=20.91$, $p<.01$) since there was no significant difference between the two types of complex items (effect of the type of syllabic complexity ($F(1,56)=2.45$, ns).

Table 1. Mean Number of Correct Responses in Reading and Spelling[a]

	CVC/CVC	CCV/CVC	CV/CV/CV
		Reading	
January	2.05	2.04	3.16
	(2.68)	(2.63)	(2.74)
June	5.79	5.33	6.11
	(2.64)	(2.68)	(2.10)
		Spelling	
January	2.60	2.58	4.49
	(2.88)	(2.94)	(2.59)
June	5.19	5.23	6.54
	(2.71)	(2.58)	(2.04)

[a]Standard deviation are in parentheses

Spelling: Analysis of correct responses

As with reading, performance was significantly better in the second session than in the first session, 40% of correct responses for session 1 as opposed to 71% for the second session. A 2 way ANOVA indicated a significant effect of session ($F(1,56)=78.21$, $p<.01$), an effect of syllabic structure ($F(2,112)=37.63$, $p<.01$), and no significant Session x Syllabic Structure interaction ($F(2,112)=1.61$, NS). The syllabic structure effect was a result of greater number of correct responses for the items with a simple structure (complexity effect: $F(1,56)=57.90$, $p<.01$).

However, the type of syllabic complexity had no significant effect on performance ($F(1,56)<1$, ns).

In summary, the data showed similar patterns of development in reading and spelling. Difficulties in reading and spelling were a function of the complexity of the syllabic structure. Specifically, syllables of the type CCV or CVC were more difficult than CV syllables. Open syllables with a CCV structure were not easier than closed syllables of the CVC type.

Error analyses

Errors were grouped in three main classes, minus one errors, non responses, and atypical errors, that is errors which could not be classified in either of the two preceding categories. Minus one errors were close to the target item and differed only by one element, that is, a substitution (dirbul for tirbul), a deletion (tibul for tirbul), an insertion (tirubul for tirbul), or a sequential error (tribul for tirbul). These errors constitute a partial use of grapheme-phoneme correspondences since in these types of errors the pseudowords are accurately produced except for one grapheme in spelling or one phoneme in reading. Non responses and atypical errors indicate little or no use of GPC rules (see Sprenger-Charolles & Siegel, 1994).

The errors in reading and spelling are shown in Table 2. In reading, there was an increase of minus one errors between sessions ($t(56)=8.19$, $p<.01$) and a significant decrease in both other types of errors ($t(56)=4.87$, $p<.01$ for atypical errors and $t(56)=4.81$, $p<.01$ for non-responses).

The results were similar for spelling. The number of minus one errors increased significantly between sessions ($t(56)=2.70$, $p<.01$) and the number of atypical errors decreased between sessions ($t(56)=3.01$, $p<.01$). However, the number of non responses did not change significantly between sessions ($t(56)=0.3$, NS).

Table 2. Mean Percentage of Types of Errors in Reading and Spelling[a]

	Minus 1	**Atypical errors**	**Non-responses**
		Reading	
January	39.3 (33.4)	36.5 (28.6)	24.2 (28.5)
total number of errors	260	423	272
June	73.3 (27.3)	19.0 (21.5)	7.76(17.3)
total number of errors	201	124	61
		Spelling	
January	56.9 (32.7)	38.9 (30.1)	4.16 (10.0)
total number of errors	357	411	49
June	70.3 (31.4)	26.2 (28.8)	3.47 (14.2)
total number of errors	242	145	14

[a]Standard deviation are in parentheses

In summary, the only error type in which we observed an increase between sessions, both in reading and in spelling, was that of minus one errors. These errors involve the accurate production of pseudowords except for one phoneme in reading or for one grapheme in spelling. Therefore, this type of error may be phonologically governed.

Minus one errors

A more in depth analysis of minus one errors may allow us to examine whether this kind of error is mainly phonologically governed. Minus one errors were divided in 4 subcategories. These included deletions ("tirbul" spelled as "tibul"), substitutions ("tirpul" for "tirbyl"), sequence errors ("tribul" for "tirbul") and insertions ("tiribul" for "tribul"). The analysis of these different types of errors allows the examination of specific hypotheses concerning the stability of different elements in the syllabic structure as a function of their place and their nature. In addition, these analysis can provide the answers to question related to the visual or phonological nature of processing in reading and spelling. The analyses reported below were derived from the examination of the percentage of errors for each minus one error categories.

There were a large number of substitution and deletion errors. Concerning substitutions (see table 3) in both reading and spelling, these kinds of errors involved primarily consonants as opposed to vowels, more than 90% of substitutions in reading for sessions 1 and 2 and more than 77% in spelling for the same sessions. In addition, in most cases vowels were replaced by vowels and consonants by consonants; replacement of consonants by vowels or the reverse was rare. Moreover, the replacements were in the same phonological category, stops by stops, fricatives by fricatives, and liquids by liquids, in 93 and 97% of the cases for sessions 1 and 2 in reading and in 88% and 86% of the cases in spelling.

Substitutions between the stop consonants p, b, t and d were examined. For this comparison, we considered the total number of substitutions between those four stops and calculated the percentage of error for each possible substitution (p/b, t/d, b/d, p/t, p/d and b/t). We observed that there were very few substitutions between consonants that differed by more than one phonological features, less than 5% of substitutions were between p/d and between b/t. Consequently, the great majority of substitutions concerned consonants that shared all the phonological features excepted one, that is, voice/voiceless substitutions between p/b or between t/d on the one hand and, on the other hand, place of articulation substitutions between b/d or between p/t. A great proportion of these errors concerned a change of the voicing feature (from 64 to 73%). This was true for all sessions, excepted the first reading ones where only 51% of the substitutions were voice/voiceless substitutions. As a result, except for session 1 in reading, a smaller proportion of substitutions concerned a change in the place of articulation. A more in deepth analyses for voice/voiceless substitutions, showed that, in both sessions and in both modalities, only 14 to 23% of the total proportion of substitutions involved the visual similar stops p/b as opposed to 37-53% for t/d. In fact, except for the first reading session, a half of the substitution errors between stops were between the non visual similar consonant t and d. The opposite trend was observed for place of articulation substitutions. Changes between p and t were virtually non existent in reading and spelling. This was not the case for the visually similar stop consonants, b and d; approximately 25% of the total proportion of substitutions for stops were between b and d for all sessions except the first reading session where this kind of substitution was very frequent (49%). Therefore, except for session 1 in reading, errors which are typically called visual errors (p/b and b/d substitutions) were not the most frequent errors for

stops. In summary, results for substitution between consonants indicated that, in most of the cases, the phonological properties of items explained most of these kinds of errors.

As compared to consonants, a small proportion of substitution errors involved vowels: 8 and 9% for the two reading sessions, 20 and 14.5% for the two spelling sessions. Thus we examined substitutions between vowels for the two sessions and the two modalities (i.e. 54 of the 409 total number of substitution errors). These vowel substitutions involved primilarly a change between the high front vowel i (/i/) and the high middle vowel u (/y/) or a change between the latter vowel and the high back ou (/u/) (respectively, 23 and 13 out 54). We never observed a substitution between the more distant high vowels, /i/ and /u/. Therefore, as it was the case for consonant errors, vowel substitutions appear to be, at least in part, phonetically governed.

Table 3 Substitutions Errors in Reading and Spelling (Percentage)

Error type	**Reading**		**Spelling**	
	January	**June**	**January**	**June**
Vowel/Vowel	08	09	20	14.5
Consonant/consonant	92	91	77	81,5
Vowel/consonant	00	00	03	04
Consonants from the same phonological category	93	97	88	86
Total for voice-voiceless substitutions	51	73	64	73
p/b	14	23	17	20
t/d	37	50	47	53
Total for place of articulation substitutions	49	24	32	27
b/d	49	24	26	23
p/t	0	0	06	04
Total for voicing and place of articulation	0	02	04	0
Total number of substitution errors	92	115	105	97

Deletions in reading and spelling (see table 4) consisted primarily of consonants, 67 and 81% of deletions for sessions 1 and 2 in reading, 85 and 77% in spelling. Consonants in simple onsets were rarely omitted (0 to 12% of cases); however, consonants in complex onsets were most frequently deleted (63 and 16% in reading and 38 and 45% in spelling). The percentages of deletions for codas ranged from 37 to 84% in reading and from 50 to 51% in spelling. Moreover, the second element in the complex onset was usually the one that was omitted (the most sonorant in the list, e.g., liquids, in 90-100% of the cases for each of the two sessions in reading and spelling). The least stable codas were intersyllabic codas in spelling (for sessions 1 and 2: 83 and 73% of deletions as opposed to 17 and 27% for the codas at the end of a pseudoword). However, in reading, the codas at the end of pseudowords were typically omitted (in 87 and 62% of the cases).

Table 4. Deletion Errors in Reading and Spelling (Percentage)

	Reading		Spelling	
	January	**June**	**January**	**June**
Consonants	67	81	85	77
Vowels	33	19	15	23
Consonants in simple onset	00	00	10	10
Consonants in complex onset (first syllable)	63	16	38	45
first letter (stop/fricative	10	0	10	10
second letter (liquid)	90	100	90	90
Consonants in coda (liquid)	37	84	50	51
first syllable (before onset)	13	38	83	73
second syllable (end of pseudoword)	87	62	17	27
Total number of deletion errors	124	31	227	122

There were very few insertion errors in reading and spelling (see table 5) but in 100% of the cases, the insertions were liquids. In both reading and spelling, the majority of the sequence errors (see also table 5) were within the syllable ("tirbul" replaced by "tribul" and not by "tibrul"; more than 89% of the cases in reading and spelling in both sessions).

Table 5. Insertion and Sequence errors in Reading and Spelling (Percentage)

	Reading		Spelling	
	January	**June**	**January**	**June**
Insertion errors				
Vowel	60	27	25	55
Consonants	40	73	75	45
Total number of insertion errors	18	27	12	9
Sequence errors				
Inside the syllable	92	89	100	93
Outside the syllable	08	11		07
Total number of sequence errors	26	33	13	14

In summary, the analysis of minus 1 errors showed that the phonological properties of items were a significant predictor of responses. The only result that did not fit entirely with a phonological explanation for errors was the high number of substitution errors between the two stops b and d in the first reading session.

Consonants and vowels

The analysis below considered consonants and vowels corrects, independently of their place. These data are shown in table 6.

Table 6. Mean Percentage Correct Responses on the Vowels and the Consonants[a]

	All items		CVCCCV		CCVCVC		CVCVCV	
	Conson. (N=88)	**Vowels (N=56)**	**Conson. (N=32)**	**Vowels (N=16)**	**Conson. (N=32)**	**Vowels (N=16)**	**Conson. (N=24)**	**Vowels (N=24)**
				Reading				
January	60.0	69.4	55.8	68.9	57.7	69.2	68.7	69.8
	(27.9)	(28.6)	(29.2)	(29.3)	(30.9)	(33.5)	29.3)	(29.8)
June	84.9	88.6	82.9	87.0	85.1	89.9	87.2	88.7
	(19.8)	(19.0)	(23.0)	(20.1)	(20.4)	(20.7)	(19.6)	(20.7)
				Spelling				
January	72.8	86.1	70.3	87.4	69.3	83.4	81.0	87.1
	(25.7)	(16.4)	(26.6)	(16.4)	(26.9)	(20.3)	(25.8)	(16.6)
June	89.8	94.7	89.3	93.5	88.9	94.2	91.7	95.8
	(15.7)	(8.2)	(16.8)	(9.52)	(17.2)	(10.6)	(16.7)	(7.91)

There were significantly fewer errors on vowels than consonants (for sessions 1 and 2, in reading and spelling, respectively, $t(56)=6.09, 4.43, 6.64, 3.81$; significant at $p<.01$). However, in certain structures (CVCCVC or CCVCVC) there were more consonants than vowels but this was not the case for other structures (CVCVCV). Therefore, we analyzed the relative frequency of consonants and vowel errors as a function of the three categories of stimuli. This analysis indicated that there were more correct responses to vowels than consonants for the CVCCVC items (for sessions 1 and 2 in reading, $t(56)= 6.59, 4.22$; and for spelling, 7.31, 2.78; significant at $p<.01$). The same results were obtained for the CCVCVC items (for sessions 1 and 2 in reading, $t(56)= 6.26, 5.60$; in spelling, 6.37, 3.35; significant at $p<.01$). However, for the CVCVCV items, there was no significant difference between the correct reading of vowels and consonants in session 1 ($t(56)=0.66$) and the difference did not reach conventional levels of statistical significance in session 2 ($t(56)=1.68$ $p<.10$). In spelling, vowels were always produced significantly more accurately than consonants in the CVCVCV items (in session 1, $t(56)= 2.98$; $p<.01$ and for session 2, $t(56)= 2.56$; $p<.02$).

In summary, in spelling, vowels were more often consistently written correctly as opposed to consonants, independently of the syllabic structure in which they occurred. There were fewer errors in the reading of vowels than in the reading of consonants, except in items with a CVCVCV syllabic structure. However, even in this case, consonants were not read more easily than vowels.

Discussion

The central hypothesis of this study was that phonological mediation plays a critical role in the early development of reading and spelling in French. Therefore, from the very beginning of the acquisition of reading and spelling, the phonological structure of items, as opposed to their visual characteristics, was expected to be a significant determinant of performance.

The first hypothesis was that syllables with a simple CV structure would be easier than those with a more complex structure, CCV or CVC, and that errors on syllables with a more complex structure would involve the deletion of codas or the simplification of complex onsets. This hypothesis was confirmed, in that items with a more complex syllabic structure were more difficult both in reading and in spelling. This effect was more marked in spelling than in reading. The results of the analyses of minus 1 errors corroborated the results obtained with correct responses in that almost all the cases of deletion errors involved the simplification of a complex onset or the deletion of a coda, that is the reduction of the syllable to its primary elements, C + V.

The second hypothesis was that errors would be consistent with the hierarchy of sonority. The analyses of deletions showed that the most sonorant consonants used in this study were deleted, whether they were in a second position after a less sonorant consonant in an onset cluster (tribul) or in the first position before a less sonorant consonant in an intersyllabic cluster (tirbul) or in the final coda of items (tirbul). Therefore, it is the phonological properties of consonants, and not the position of those consonants, that explains the majority of deletions. These results are consistent with the interpretation that errors were not primarily visual but instead were phonologically mediated.

The third hypothesis was that the principal phonological categories would be preserved in substitutions, in that vowels would be replaced by vowels and consonants by consonants belonging to the same phonological category, stops by stops, fricatives by fricatives and liquids by liquids. Analyses of substitution errors showed that this was the case even for p/b and t/d and for b/d and p/t substitutions. Although p/b and b/d substitutions are typically considered as visual, the results indicated that they can also be considered as phonological errors. If p/b and b/d substitutions are truly phonological errors, we can expect as many substitutions errors between p/b than between t/d or between b/d than between p/t since those stops share the same phonological differences (voice/voiceless for p/b and t/d; place of articulation for b/d and p/t). On the other hand, if those substitutions are truly visual errors, we can expect more p/b or b/d substitutions than p/t or t/d substitutions. The results showed that confusions between p/b and b/d were not more common than confusions between their phonological equivalents t/d and p/t, except in the first session in reading. However, differences were observed concerning voicing (p/b or t/d substitutions) and place of articulation (p/t or b/d substitutions). The first type of errors was more frequent than the second, as is generally reported in the case of speech errors (MacKay, 1992). In fact, for the first session in reading almost half of the errors among p, t, b and d were substitutions between b and d. In all the other cases, the number of t/d substitutions was greater than the number of p/b or b/d substitutions. Thus, except the results obtained for the first session in reading that show that although children have some difficulties with the left-right orientation of letters, substitution errors between stops appear to be phonological and not visual errors. Moreover, inversions of letter sequences (ri/ir), that are often considered visual errors, were observed essentially inside the syllable ("tirbul" versus "tribul" and not "tibrul"). Therefore, these errors can also be interpreted as phonological errors**.** The results observed for substitutions between consonants are consistent with those obtained with beginning readers in English (Fisher

et al., 1977; Fowler et al., 1977; Fowler et al., 1979; Liberman et al., 1971), in Serbo-Croatian (Ognjenovic et al., 1983) and in Italian (Cossu, Shankweiler, Liberman & Gugliotta, 1995). They show the phonological origin of certain types of errors often considered as visual ones. Most important, they lead to doubt the usefulness of the classifications which contrast visual and phonological errors such as were used to classify subtypes of dyslexia (Boder, 1973; Orton, 1937).

The three first hypotheses concern principles that are assumed to be general, non language-specific. In contrast, our fourth hypothesis was that, in addition to those general principles, there would be some variations depending on the characteristics of the different languages. For example, because of the frequency of open syllables in French, we expected superior performance on open syllables (CCV) in contrast with the closed syllables (CVC) and, for errors, we expected deletion of codas of the closed syllables. Moreover, because of the stability of vowels in French, we expected few errors involving vowels.

In fact, we did not find that closed syllables were more difficult than open syllables. There were no significant differences in the number of correct responses between the CCV(CVC) and the CVC(CVC) items. This finding may be the result of the difficulties that young children have with clusters of the type obstruent + liquid (see Chin & Dinsen, 1991, and Dodd, Leahy & Hambky, 1989, for English children, and Aicart de Falco & Vion, 1987, for French children). This result may be explained by the fact that in clusters of this type the second consonant has a higher level of sonority and, thus, a greater tendency to disappear.

However, our results for the comparison between vowels and consonants were different than the one generally obtained in English. In our study, we found significantly fewer errors on vowels as opposed to consonants, except in the case of the CVCVCV items in reading. Nevertheless, even in this case, the reverse was not observed, that is, consonants were not more accurately produced than vowels. In addition, the analysis of errors showed that substitutions, like deletions, were essentially with consonants. This result is the opposite of what occurs in English in that beginning readers and spellers consistently make more errors on vowels than on consonants (for reading: Bryson & Werker, 1989; Fischer et al., 1977; Fowler et al., 1977; Fowler et al., 1979; Siegel & Faux, 1989; for spelling: Stage & Wagner, 1992; for reading and spelling: Roeltgen, 1992; Treiman, 1993).

Our results differed from those obtained with English beginning readers or spellers but were similar to those obtained in other language, particularly, in Serbo-Croatian (Ognjenovic et al., 1983), in Italian (Cossu, Gugliotta & Marshall, 1995; Cossu, Shankweiler, Liberman & Gugliotta, 1995) and in German (Wimmer, 1993). Those three languages differ from English by two features. First, mapping between grapheme and phoneme is more consistent than in English, even for vowels; second, those languages have, unlike English, strong distinct vowels, without the slurring that often occurs in English.

Therefore, the results for English may be due to a combinaison of orthographic and phonological factors. The fact that in the Fowler et al. study (1977, 1979) errors on consonants, but not errors on vowels, could be primilarly explained by phonological features (voicing, place of articulation) suggests that the vowel errors in English are mainly due to the complexity and the variability of the spelling to sound correspondence for vowels. Alternatively, Ognjenovic et al. (1983) found that phonological features, that mainly account for consonant errors, also account for vowel errors, which are rare in Serbo-Croatian. Thus, considering the characteristics of the Serbo-Croatian (predictibility of grapheme-phoneme correspondences, even for vowels, stability

of vowels in speech) it can be suggested, as Ognjenovic et al. do (1983, p. 105), "that the vowel substitutions of Serbo-Croatian, like the consonant substitutions of Serbo-Croatian and unlike the vowel substitutions of English are, at least in part, phonetically governed".

In a similar manner, we observed that in French, vowel errors, which are never more numerous than consonant errors, are, at least in part, phonetically governed. Therefore, our results for vowels may be explained by a phonological factor, the high stability of French vowels, independently of the position in the word. Phonological factors can also explain why we found many errors on consonants and why those errors were mainly deletion of the most sonorant element and substitutions among consonants that share all but one phonological features.

The results of our study are somewhat limited by the use of a small number of vowels and consonants (3 out the 10 vowels and 8 out the 18 consonants, see notes 1 and 2 for an explanation). This choice was a result of the fact that we wanted to control the linguistic properties of our items. It is important to note that we found the same kind of results for errors on consonants and vowels in a previous longitudinal study in which we assessed word reading and word spelling acquisition in French (Sprenger-Charolles, 1993). In that study, only single consonant graphemes, but single vowel graphemes + some frequent complex vowel graphemes, without allographes, were used. Thus, it appears that there are systematically more errors on consonants than on vowels in French, in the beginning of reading and spelling acquisition, even when we compared single consonant graphemes and some types of complex vowel graphemes.

These results indicate that it is difficult to generalize from the data obtained in one language, whatever the language. This does not mean that there are not some general principles, common to all languages; for example, the phonological principle that phonological mediation plays a central role in reading (Perfetti, 1995), even in non-alphabetic languages such as Chinese (Perfetti & Zhang, 1995; So & Siegel, 1995). This role appears to be especially pronounced in the beginning of reading and spelling acquisition in languages in which the spelling to sound correspondences are highly regular. For example, the results of the cross linguistic study of Wimmer and Goswami (1994) have shown that, unlike in English, phonological mediation appears to be operating even in the very beginning of reading in German, and that a logographic stage does not seem to exist in German (see also Wimmer & Hummer, 1990). We found the same result (no clear evidence of logographic strategies as described in developmental models) in a longitudinal study dealing with French children followed from the beginning of the last year of the kindergarten to the end of the first grade (Sprenger-Charolles & Bonnet, 1996) and in two other ones in which we assessed reading and spelling performances in the first grade (Sprenger-Charolles & Casalis, 1995; Sprenger-Charolles, Siegel & Béchennec, 1996).

These results show that some of the conclusions of the reading/spelling developmental models may be biased because research has primilarly been conducted in English, a language whose orthography is highly irregular. Future research in languages other than English, as well as cross linguistic studies with detailed phonological analyses, are therefore needed to clarify what is general and what is specific, that is language dependent, in reading and spelling acquisition.

Notes

1. Glides were non included.
2. There are only 10 vowels in French if we do not take into account two phonological differences which tends to disappear; first, the difference between open and closed vowels (for "a", "o", "e" and "é" versus "è"), and, second, the difference between the two nasal vowels "un" and "in".
3. Those items were used in another experiment, to assess the lexicality effect in reading and spelling (see Sprenger-Charolles, Siegel & Béchennec, 1996)

Appendix

CVC/CVC	CCV/CVC	CV/CV/CV
tirbul	tribul	tibulo
bultir	blutir	butiro
puldir	pludir	pudiro
dirpul	dripul	dipulo
tirvul	trivul	tivulo
vultir	vlutir	vituro
fuldir	fludir	fudiro
dirful	driful	difulo

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